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VOL. 4 No. 3

# JOURNAL OF THE TELEVISION SOCIETY

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# THE TELEVISION SOCIETY

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# THE JOURNAL OF THE TELEVISION SOCIETY

Vol. 4. SEPTEMBER, 1944. No. 3.

## SOCIETY NOTES

### MEETINGS.

At an Ordinary Meeting of the Society held at the Institution of Electrical Engineers on Saturday, June 3rd, 1944, a paper was read by Dr. A. Sommer (Cinema-Television) on "The Colour Response of Photo-Electric Cells," with demonstration. The paper is reported in this issue of the *Journal*.

It was announced that the meetings of the Society would be suspended throughout the summer months and be resumed in October. Members will be notified as to the date of the meetings in due course.

### REVISION OF THE SOCIETY'S BYE-LAWS.

For some time the Council of the Society has had under consideration the revision of some of the Society's rules in order to bring them more in keeping with the trend of the Society's interests.

A Committee of the Honorary Officers and Mr. A. H. Bennett (Member of Council) was deputed to make recommendations to Council which, when approved, would be in turn submitted to Members at an Extraordinary General Meeting.

It is felt, however, that on any questions affecting the Society's constitution it would be essential to have the views of all Members, and the Council's resolutions are accordingly being circulated for a postal vote.

### BALANCE SHEET FOR 1943.

The Balance Sheet for 1943 has been approved by the Council and will be submitted to Members at the Extraordinary General Meeting.

### LIBRARY.

The following books have been added to the Society's Library:—

- Thermionic Valve Circuits, E. Williams (Pitman and Sons).
- Gaseous Conductors, J. D. Cobine (McGraw-Hill).
- Radio and Telecommunications Engineers' Design Manual, R. E. Blakey (Pitman and Sons).
- Plastics in the Radio Industry, E. G. Couzens (Hulton Press).

### MEMBERSHIP.

The following new Members have been elected since January, 1944:—

Benham, W. E.—Tunbridge Wells.
Belschner, F. W.—Eltham.
Cary, R. O.—London, W.8.
Disney, A. L.—Dunstable.
Lewis, D. L.—Queen's Park.
McMullen, D.—Wallingford.
Patchett, G. N.—Bradford.
Prosser, D. P.—Haslemere.
Saw, P. D.—Thames Ditton.
Sommer, A.—Beckenham.
Stevens, W. H.—Edgware.
Thompson, A.F.—London S.E.1.

### "THE JOURNAL."

Arrangements have been made to produce the Society's *Journal* quarterly instead of three times yearly as hitherto.

The volume will, therefore, consist in future of twelve issues, covering three years.

This has necessitated a revision in the price charged to non-members for copies of the *Journal*, which is now £1 0s. 0d. per annum instead of 15/-. The revised prices for bound volumes are as follows:—

| | Members. | Non-Members. |
|---|---|---|
| Leather Case ... | 41/- ... | 51/- |
| Blue Cloth Case ... | 39/6 ... | 49/6 |

(Packing and Postage 1/- extra in each case).

Orders for bound volumes should be sent direct to the Society's printers: Messrs. Blacket Turner and Co., Northbrook Street, Newbury, Berks, and *not* to the Editor.

Orders for the supply of issues to non-members should be sent to the Hon. Editor, 68, Compton Road, London, N.21.

Members are reminded that copies of the *Journal* can be posted to their friends on Active Service abroad, who would probably be pleased to keep in touch with television developments. Orders should be sent to the Editor, together with remittance at the special rate of 2/6 per copy.

## MEMBERS ON ACTIVE SERVICE.

The records show a number of Members on active service in this country or overseas, and it is thought that publication of their names would enable fellow members to get in touch with them if they are in the same part of the country.

Among the notifications of Service Members received are:—

**W. R. Bates**—C.M.F., Italy.
**T. H. Bridgewater**—W/Co., R.A.F., England.
**W. H. Cazaly**—Capt., R.E.M.E., England.
**S. T. Chrees**—Sigmn., B.L.A.
**N. S. Cinderey**—F/O., R.A.F., England.
**G. V. Haylock**—Sigmn., C.M.F.
**H. Jones**—Lt., R.N.V.R., England.
**D. R. Lovell**—R.A.F., England.
**A. H. Lunn**—Ft./Sgt., R.A.F., C.M.F.
**P. Ryan**—Capt., Sigs., England.
**P. J. Wheatley**—R.A.F., India.

The Editor will be pleased to give full addresses on application and invites further particulars of serving Members.

## TRANSLATIONS.

Miss A. Everett, a member of long standing, is willing to undertake technical translations or similar work in connexion with the national effort. Enquiries should be addressed to either of the Hon. Secretaries.

## THE BRITISH STANDARDS INSTITUTION.

In view of the growing importance of standardisation in the radio and television industry, the Society has applied for membership of the British Standards Institution.

The Institution, which has offices at 28, Victoria Street, S.W.1, was formed in 1901 as the Engineering Standards Committee, and was incorporated in 1918 as the British Engineering Standards Association (BESA). Its title was later changed to that of the British Standards Institution, and it is accepted as the national organisation for the promulgation of British Standard Terms, definitions, codes of practice, and specifications of materials, articles and tests.

Copies of the specifications are filed in the Society's Library, and are available for consultation on request.

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# APPRECIATION

### Mr. W. C. KEAY,
### The Society's First Honorary Treasurer.

Mr. W. C. Keay, whose resignation from the post of Honorary Treasurer was briefly announced in the last issue of the *Journal*, is one of the Founder Members of the Society, and was in fact elected to the Treasurership at the first General Meeting. He has therefore held the office with distinction for seventeen years.

A native of Angus, Mr. Keay was a contemporary of Mr. J. L. Baird at the Glasgow Royal Technical College, where he was awarded the Armitstead Medal—a very high distinction. He was also the Editor of the College Magazine.

In later years, when Mr. Baird had travelled South, Mr. Keay assisted him in some degree to obtain recognition of his pioneer work and was present at many historical "firsts," including the first U.S. transmission and the Berengaria demonstration. He also had a hand in fitting up a television receiver in 10, Downing Street, the first occasion on which various delegations were enabled to see television for themselves.

During the whole of Mr. Keay's tenure of office, the Society's finances have been maintained in a most satisfactory state without a hitch, and his vigilance has saved the Society from unnecessary expenditure on more than one occasion. He is particularly anxious to point out that his work has been lightened throughout the time by the enthusiasm and co-operation of his colleagues, and in particular Mr. Denton.

Mr. Keay has been in practice as a consulting engineer for many years, and at present holds an appointment with the Board of Trade. It is this exacting work which has compelled him to resign his office, but he will continue to take the keenest interest in the Society's affairs, and his advice is always at the disposal of officers who succeed him. At the Council meeting following his resignation, the following resolution was minuted:—

> "That the best thanks of the Society be awarded to Mr. W. C. Keay on his resignation from the Honorary Treasurership, together with the Council's deep appreciation of his untiring work on its behalf."

We are sure that this resolution will be cordially endorsed by all members.

# THE COLOUR RESPONSE OF PHOTOELECTRIC CELLS

By A. SOMMER, Dr. ING (Fellow).*

A Paper read before the Society on June 3rd, 1944.

## INTRODUCTION.

I SHALL confine myself in this paper to photo-electric cells of the emission type, i.e., cells in which light releases electrons from the photo-electrically sensitive cathode which are subsequently collected by a second electrode, the anode. (Photo-electric cells of the barrier-layer and Selenium type are of no interest to the television engineer because of their low internal resistance and their time lag in the detection of high frequency signals). The first part of the paper will deal with the theory of photo-electric emission and in the second part it will be shown how this theory agrees with the properties of the known types of photo-electric cells and what predictions it enables one to make with regard to future developments.

## THEORY OF PHOTO-ELECTRIC EMISSION.

A theory of photo-electric emission has to explain the results of fundamental experiments which have been carried out to investigate the relationship between the number and the velocity of photo-electrons and the intensity and wave-length of the radiation releasing these electrons. In these experiments (which can only be summarised here) the number of electrons is measured in form of the photo-electric current flowing from the cathode to the anode. The velocity of the electrons is measured in electron-volts by gradually increasing the anode potential from a negative value of several volts through zero to positive values. Obviously, while the anode is negative only electrons which are leaving the cathode with a velocity equal to or greater than the anode potential are able to reach the anode while with an anode potential of zero or of positive value all electrons should go to the anode.

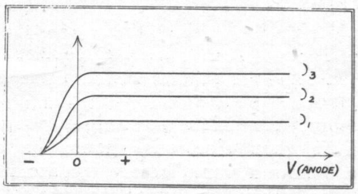



FIG. 1—Photo-current v. anode potential for various intensities but constant wavelength.

In *Fig. 1*, the photo-current is plotted against the anode potential for radiation of constant wave-length but varying intensity. It can be seen that with increasing anode potential, i.e., as the required minimum initial velocity of the photo-electrons decreases, the photo-current increases to reach its maximum at zero anode volts and remains constant at positive anode potentials. Two more facts can be seen from the curves: Firstly, all the curves cut the abscissa in the same point, i.e., the maximum velocity of the photo-electrons is independent of the light intensity. Secondly, the photo-current increases with increasing light intensity, the number of photo-electrons is actually proportional to the light intensity.

*Fig. 2* shows the effect of light of constant intensity but varying wavelength on the photo-electric emission. The series of curves indicates that at zero anode volts the same current is obtained in each case. However, the curves cut the abscissa at different points, in other words the maximum velocity of the electrons depends on the wave-length of the light. The shorter the wave-length the greater is the maximum velocity.

The described experimental results were all satisfactorily explained by Einstein's theory. Einstein based his theory on the quantum theory according to which light is emitted and absorbed

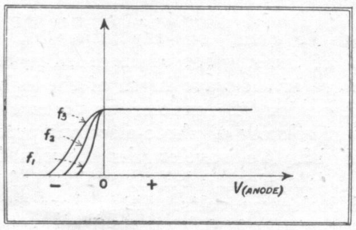



*Fig.* 2—Effect of varying wavelength, with constant intensity.

in distinct units or "light quanta" of the size $h\nu$. In this expression $h$ represents Planck's constant and $\nu$ the frequency of the light. If photo-electric emission takes place, these energy units $h\nu$ are, according to Einstein, converted into electronic energy, which is represented by the product $eV$, where $e$ stands for the electronic charge and $V$ for the velocity of the electron in

* Cinema-Television Ltd.

electron-volts. Hence the conversion of energy of radiation into electronic energy can be expressed by the simple equation

$$eV = h\nu \qquad (1)$$

By using the well-known relation $\lambda = \frac{c}{\nu}$ (where $\lambda$ denotes the wavelength and $c$ the velocity of the light) we obtain:

$$eV = \frac{hc}{\lambda}$$

The terms $h$, $c$ and $e$ are universal constants and can be replaced by their numerical values. This leads to the equation

$$V = \frac{12336}{\lambda} \qquad (2)$$

if $\lambda$ is expressed in Angstrom units and $V$ in volts.

PERIODIC SYSTEM

| I | | II | | III | | IV | | V | | VI | | VII | | VIII | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | | | | | | | | | | | | | | | He |
| Li | | Be | | B | | | C | | N | | O | | F | | Ne |
| Na | | Mg | | Al | | | Si | | P | | S | | Cl | | A |
| K | | Ca | | Sc | | Ti | | V | | Cr | | Mn | | Fe Co Ni | |
| | Cu | | Zn | | Ga | | Ge | | As | | Se | | Br | | Kr |
| Rb | | Sr | | Y | | Zr | | Nb | | Mo | | - | | Ru Rh Pd | |
| | Ag | | Cd | | In | | Sn | | Sb | | Te | | J | | X |
| Cs | | Ba | | La | | Hf | | Ta | | W | | Re | | Os Ir Pt | |
| | Au | | Hg | | Tl | | Pb | | Bi | | Po | | - | | Rn |
| - | | Ra | | Ac | | Th | | Pa | | U | | | | | |

Fig. 3—The Periodic System of the elements.

It is obvious that the Einstein equation explains the curves of *Figs. 1* and *2*. The velocity of the photo-electrons depends only on the wavelength of the light, but not on its intensity, because it is determined solely by the " size " of the light quanta $h\nu$ and not by their number. The number of photo-electrons, on the other hand, is a function of the number of absorbed light quanta irrespective of the wavelength of the light.

The equation (2) enables us to calculate the maximum velocity of photo-electrons produced by visible light. To wavelengths between 4000 and 8000 Å (Angstrom) belong values of between 1·5 and 3 electron volts. But these are not the velocities with which the electrons are released from the sensitive cathode because they have first to overcome attracting surface forces which correspond to a loss of velocity equal to $\phi$ volts, the so-called " work function," which is dependent on the chemical nature of the sensitive surface. To obtain the actual velocity with which the photo-electrons are released, we therefore have to modify the Einstein equation to

$$V = \frac{12336}{\lambda} - \phi \qquad (3)$$

The electrons can, of course, only leave the surface if $V$ is zero or positive. Hence the longest wavelength which can produce photo-electric emission is

$$\lambda_o = \frac{12336}{\phi} \qquad (4)$$

This equation is very useful, either to calculate the work function if $\lambda_o$, the so-called " threshold wavelength," is known or to determine the threshold wavelength for substances of known work function. Here we are only interested in the second case. It can be seen at once that only for substances with a work function $\phi \leqq 3$ volts photo-electric sensitivity for visible light ($\geqq$ 4000A) can be expected.

## CONDITIONS OF PHOTO-ELECTRIC EMISSION.

After understanding the fundamental mechanism of the photo-electric effect we come now to the application of this knowledge in making photo-electric cells of high sensitivity. At this point it may be worth while to consider what substances can theoretically be expected to be good photo-electric emitters. I should like to name four main conditions.

Firstly, the substance has to absorb light. This condition excludes or limits the use of many substances. Transparent materials like glass, mica and all colourless salts are obviously unsuitable. But also substances of high reflecting power are in this category; that means most pure metals. To take Silver and Aluminium as examples which reflect almost 100 per cent. of the visible light, only a very small photo-electric sensitivity could be expected from these metals.

A second condition for high photo-electric emission is that electrons should be available which are bound very loosely by atomic forces. Here it is useful to refer to the " Periodic System " and to its explanation by Bohr's model of the atom. The Periodic System (*Fig. 3*) owes its origin to the observation that certain elements are very closely related to each other, for instance the alkali metals, the rare gases, etc. According to Bohr all atoms consist of a positive nucleus surrounded by fixed orbits of electrons. Each orbit can only accommodate a limited number of electrons. The chemical properties of the elements are mainly determined by the electrons in the outermost orbit.

Referring to *Fig. 4* it can be seen that, for instance, all alkali metals (first group of the Periodic System) contain one electron in the outermost orbit, all earth alkali metals (second group) contain two, and so on. The rare gases are distinguished by a completed outer orbit.

If we consider qualitatively the forces by which an electron in the outermost orbit is attracted by the nucleus, it is obvious that the further removed the electron is from the nucleus the smaller will be the attracting forces. It can also be shown that the smaller the number in the outermost orbit the smaller are the attracting forces penetrating to it. The energy required to release one electron from the attracting forces, i.e., to ionize the atom, is the ionization energy. This should therefore decrease firstly with the number of electrons in the outer orbit, i.e., the more we go from the right towards the left side of the periodic system. Secondly it should decrease with increasing atomic weight, i.e., as we go from the top towards the bottom line of the periodic system. Table 1 shows that the values for the ionization energies of various elements are in perfect agreement with expectation: $E_i$ is lowest for the alkali metals (with only one electron in the outer orbit) and among the alkali metals lowest for Cæsium (in which the electron is at the greatest distance from the nucleus).

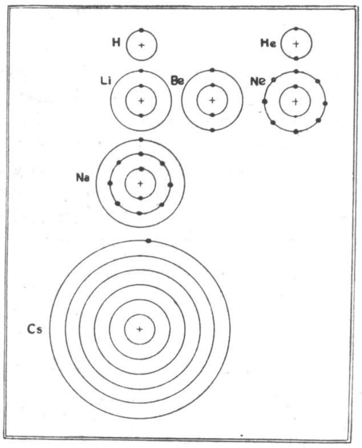



FIG. 4—Arrangement of electrons in the orbits of the alkali metals.

A third condition for high photo-electric emission is, naturally, a low work function. The work function of chemical elements seems to be in some relationship to the ionization energy. Table 1 shows that elements with low ionization energy have also low work function and vice versa. It should be mentioned that the figures for the ionization energies are based on spectroscopic measurements and are very accurate, while those for $\phi$ are based on thermionic and photo-electric measurements which are much less accurate.

The fourth and last condition for good photo-sensitivity is that neither a very good conductor nor an insulator can be expected to yield good results. The disadvantage of a conductor is that electrons produced at some depth will suffer too many collisions with other electrons on their way to the surface; in the insulator, on the other hand, it is almost impossible to replace electrons removed by the photo-effect from the depth of the material.

## MANUFACTURE AND PROPERTIES OF VARIOUS TYPES OF PHOTO-ELECTRIC CELLS.

We come now to the consideration of practical photo-cells. The first photo-electric cathode consisted of a zinc plate which responded to ultra violet light only. The absence of sensitivity for visible light is due to the fact that the work function of zinc is 3·5 volts. Referring to equation (4), it can be seen that a work function of over three volts makes a response to visible light impossible.

Photo-electric sensitivity for visible light was first observed with alkali metal cathodes. The results with alkali metals showed that the sensitivity is shifted from shorter to longer wave-lengths in the sequence Lithium to Cæsium. This influence of the position of the cathode material in the periodic system on the photo-effect was to be expected. (See page 52 above). It can be stated here already that even in all modern photo-electric cells with cathodes of a more complicated structure the presence of an alkali metal has been found essential if sensitivity to visible light is required. The sensitivity shift to longer wave-lengths from Lithium to Cæsium is also found in all known cells. The main fault of the pure alkali metal cells was their extremely low quantum yield, i.e., the great number of light quanta required to release one electron. As compared with the theoretical maximum yield of one photo-electron for each light quantum $h\nu$ in these cells approximately 100,000 light quanta are required to produce a single photo-electron.

The plain alkali cathode was superseded by the alkali hydride cathode. By passing a discharge in Hydrogen between the cathode, i.e., the alkali metal and the anode, alkali hydrides were formed with simultaneous increase of photo-electric sensitivity. As pure hydrides are not photo-sensitive, the improved sensitivity must be due to a mixture of free alkali metal and hydride. Although the alkali-hydride cathodes were a

considerable improvement as compared with the plain metal cathodes, I shall not describe their manufacture in any detail because they are now completely out-of-date, partly owing to their instability and partly because of the much greater sensitivity of later cells.

We come next to the so-called Silver-Oxygen-Alkali cell which has been until recently practically the only type of cell commercially used, because of its great response to visible light. Even now, after being known for more than 15 years, this cell is still made by a process which is more empirical than scientific and is modified by every manufacturer.

In the following I shall confine myself to describing the manufacture of the Silver-Oxygen-Cæsium (*Ag-O-Cs*) cell, which is more important than the cells containing other alkali metals. The process is essentially the same with Potassium and Rubidium.

To begin with, the cathode consists of a silver base layer which can be and is produced by different methods. One way is to mount a solid

IONISATION ENERGY $E_i$ AND WORK FUNCTION $\phi$ OF ELEMENTS

| | $E_i$ | $\phi$ | | $E_i$ | $\phi$ |
|---|---|---|---|---|---|
| Li | 5·4 | 2·2 | Cu | 7·7 | 4·3 |
| Na | 5·1 | 2·0 | Ag | 7·6 | 4·5 |
| K | 4·3 | 1·8 | | | |
| Rb | 4·2 | 1·8 | Fe | 7·9 | 4·7 |
| Cs | 3·9 | 1·7 | Mo | 7·4 | 4·1 |
| Mg | 7·6 | 2·4 | He | 24·5 | |
| Ca | 6·1 | 2·3 | Ne | 21·5 | |
| Sr | 5·7 | 2·0 | A | 15·7 | |
| | | | Kr | 13·9 | |
| | | | X | 12·1 | |

TABLE I.

silver plate on a pinch; the alternative is to produce a silver layer on the inside wall of the glass bulb itself and there exist two methods of doing this. Firstly, the silver can be evaporated from a directly heated filament consisting preferably of tungsten wire. The alternative is chemical deposition by the process which is used in mass production of thermos flasks.

Once the silver base has been produced, the cell is pumped and baked in the usual manner. The next step consists of oxidising the silver layer superficially. This is done by producing a discharge in oxygen between cathode and anode with a positive potential of several hundred volts at the anode. The process of oxidation is easily ...ved as the surface goes gradually through ... surface colours in the sequence ... blue, green, brown. There are many opinions as to the stage at which to stop the oxidation, but the blue-green seems to be about the best colour. The oxygen is pumped out after the desired colour is reached and the next step is to introduce the alkali metal. Here arises the difficulty that alkali metals must not be exposed to air in order to prevent them from being oxidised. It is therefore necessary to produce the cæsium within the cell or in a side tube after a good vacuum has been obtained. There are many ways of making metallic cæsium, the principle is in all cases to reduce a cæsium *salt*, for instance chloride or chromate, by heating it with a metal of high evaporation temperature like calcium, aluminium or zirconium. The next stage of the process is the most important and critical part of the manufacture: the right quantity of cæsium has to be distilled on to the silver oxide, the difficulty being that too much and too little cæsium are equally detrimental. The correct quantity can best be judged by the change of surface colour and of the photo-current, but long practical experience is necessary.

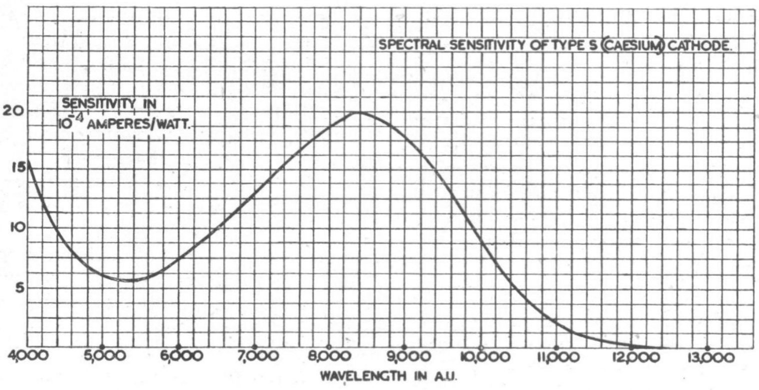
Finally, the cell has to be baked to accelerate the reaction of cæsium with silver-oxide to silver and cæsium-oxide.

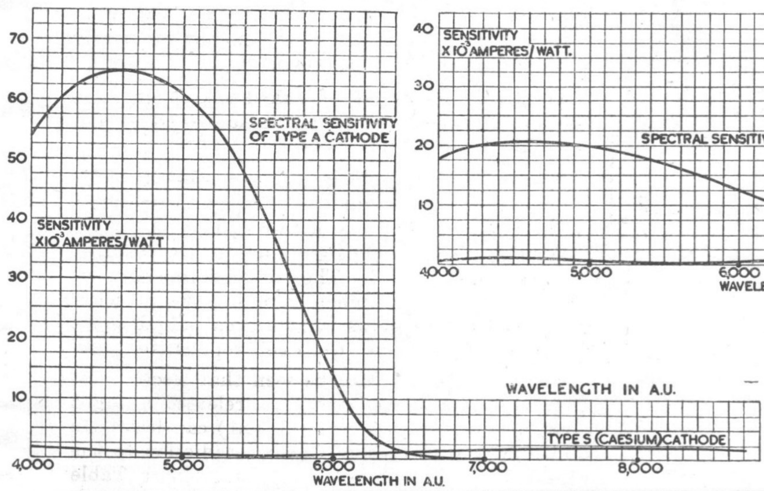
The spectral sensitivity curve of the *Ag-O-Cs* cathode is shown in *Fig. 5*. The quantum yield at the maximum, in the infra-red, is of the order of only 0·5%, i.e., 200 light quanta are required to release one electron. The fact that this figure is 100 to 1,000 times higher than for the cathodes mentioned before shows what a great advance the development of the *Ag-O-Cs* cell represented.

From the curve it can be seen that electrons of less than 1·5 volts velocity (i.e., released by light of wavelengths greater than 8000*A*) can leave the surface which seems to be in contradiction to the value of the work function of *Cs* given in Table (1), according to which the threshold wavelength should be shorter than 8000*A*. The explanation for the improved emission of this and other composite materials as compared with pure metals is as follows.

The values for ionization energies and work functions in the table are those of neutral atoms of the elements. In cases like the alkali-hydride or the silver-oxygen-alkali photocell, we have individual metal atoms adsorbed to a metal hydride or oxide. This means that the centres of positive and negative charge no longer coincide as they do in the atoms of cæsium metal in bulk; in other words, the cæsium atom is polarised. This polarisation results in the electron of the outer orbit being less tightly bound to the nucleus than in the neutral atom, with the effect that ionization energy and work function are lower

SPECTRAL SENSITIVITY CURVES



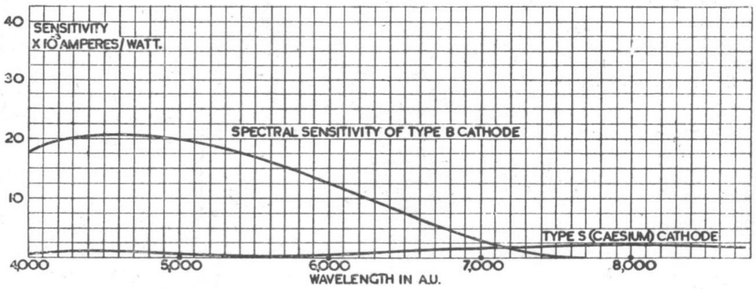




FIG. 5 (above)—Sensitivity of Ag-O-Cs cathode.

FIG. 6 (left)—Sensitivity of Sb-Cs cathode.

FIG. 7—Sensitivity of Sb-BiCs cell.

than those of the neutral atom. The actual conditions are probably more complicated than in this crude picture, but in principle it is proved by many experiments. For instance, in the cells described so far it has been found that a small amount of metallic alkali is essential: the oxides and hydrides alone are not sensitive. Of course, there is a close relationship to the case of thermionic cathodes of the barium oxide type, in which traces of free metal are considered necessary for high emission.

During the last few years, a new type of cell has become more and more important. Again alkali metals are an essential part of the photo-electric layer, but this time in the form of alloys with other metals, mainly antimony and bismuth. I shall confine myself to the most frequently used cell of this type, the Antimony-Cæsium cell, which is made in the following way: A layer of antimony is produced either on a metal base or directly on the glass by evaporating antimony from a filament. The cæsium is then produced and distilled on to this layer in a similar way to that described previously for the distillation on to silver oxide. The final alloy has several remarkable properties. Firstly, it is transparent for red light; secondly, it has lost all metallic reflection; thirdly, the specific resistance is about $10^6$ times higher than that of either of the components; and fourthly, as a photo-electric cathode it has a quantum yield of 20% at the peak of its spectral sensitivity curve (*Fig. 6*), that is, about 40 times higher than the maximum yield of the Silver-Oxygen-Cæsium cell. (It should be

noted that the scale of *Fig. 6* is reduced by the factor 10 as compared with *Fig. 5*. The curve of *Fig. 5* is re-drawn in *Fig. 6* for comparison). The peak of the curve is at 4600*A* near the blue end of the visible spectrum.

To find some explanation for the peculiar properties of the Antimony-Cæsium alloy, I made some quantitative experiments which proved that the alloy contains *Sb* (Antimony) and *Cs* (Cæsium) in the exact ratio 1 : 3. This fact, in conjunction with the non-metallic physical properties, indicates that we are dealing with a chemical compound, a so-called " intermetallic " compound, as distinct from an ordinary alloy with metallic properties and containing its component metals in almost any desired ratio.

The $SbCs_3$ layer is a good proof for the validity of the four conditions for photo-electric sensitivity. (See page 52). The transparency for red light means that red light is not absorbed, hence photo-electric sensitivity for red light is impossible. Ionization energy and work function are very low because the layer contains cæsium and, as in the *Ag-O-Cs* layer, cæsium atoms are adsorbed to a cæsium compound. Lastly, the specific resistance of the layer is considerably higher than that of metals but below that of insulators.

Finally, I should like to mention a recently developed layer of a more complicated structure. It contains bismuth and cæsium, but details of its manufacture cannot be given because we are still in the experimental stage. The sensitivity curve of this layer is shown in *Fig. 7*; it can be seen that the position of the peak is similar to that of the $SbCs_3$ layer. The interesting point is that while the quantum yield is actually lower, the sensitivity extends much further into the red range of the spectrum.

## CHOICE OF THE MOST SUITABLE PHOTO-CELL FOR VARIOUS LIGHT SOURCES.

The sensitivity of a photo-cell is usually stated in microamperes per lumen ($\mu A / L$). This value in itself would not mean anything without definition of the light source, because the term lumen is based on the colour-response of the human eye, that is, a lumen of blue or red light contains more energy than a lumen of green-yellow light, to which the eye is most sensitive. In the invisible part of the spectrum the term lumen loses all sense, though the photo-electric sensitivity to infra-red or ultra-violet light might be very important. Therefore it is customary to state the sensitivity of photo-cells in $\mu A / L$ for the light of a standard source, i.e., an incandescent lamp of the colour temperature of 2848 °*K*.

The spectral distribution of the light emitted by a body of this temperature is given by Planck's law of radiation. In Table (II) is shown how the spectral distribution depends on the temperature. It can be seen that at beginning red heat only ·001% of the radiation is visible. Even at the temperature of a normal tungsten lamp only 4 to 8% are visible and all the remainder of the radiation lies in the infra-red. It can also be seen that the greatest percentage of visible light is emitted at the temperature of the sun, showing how marvellously the human eye is adapted to the only light source which is available under natural conditions. To come back to the tungsten lamp, the table shows how much the emission depends on comparatively small variations of the filament temperature, which means that two photo-cells of different spectral sensitivity will have quite different sensitivity in $\mu A / L$ when measured with two lamps of slightly different temperature. In practice, of course, it is very difficult to measure the temperature of the lamp used or to avoid variations when using different lamps. A further disadvantage of referring to a tungsten lamp as a standard is the high " priority " that is given to the infra-red end of the spectrum. Even at the standard temperature (which is higher than the temperature of most practical lamps) the maximum of the emission is still in the infra-red.

ENERGY (IN % OF TOTAL ENERGY) EMITTED IN VARIOUS REGIONS OF THE SPECTRUM AS FUNCTION OF TEMPERATURE

| TEMP (°K) | λ< 4000A | λ= 4000-7600 | λ> 7600 |
|---|---|---|---|
| 1000 (DULL RED HEAT) | – | 001 | 100 |
| 2000 (RED-YELLOW) | 0017 | 1·43 | 98·6 |
| 2400 (TUNGSTEN LAMP) | ·02 | 4·28 | 95·7 |
| 2800 (TUNGSTEN LAMP) | ·11 | 8·78 | 91·1 |
| 3000 (TUNGSTEN LAMP) | ·22 | 11·51 | 88·3 |
| 5000 | 6·8 | 37 8 | 55·5 |
| 6000 (SUN) | 14·2 | 43·4 | 42·5 |
| 10.000 | 48·3 | 35·7 | 16 |

TABLE II.

To demonstrate the effect on measuring the sensitivity of photo-cells, I refer once more to the spectral curves of *Figs. 5, 6* and *7*, in which the sensitivity is given for equal energy at each wave-length. *Fig. 8* shows the same curves corrected for the emission of a tungsten lamp so that the area covered by each curve corresponds to the sensitivity of the particular cell in $\mu A / L$. It can be seen that this measurement is very unfavourable for the $SbCs_3$ cell. If sensitivity to light sources other than hot bodies like discharge tubes and fluorescent screens is required, the $\mu A / L$ value gives no indication at all as to which is the most suitable cell. The best thing to do is

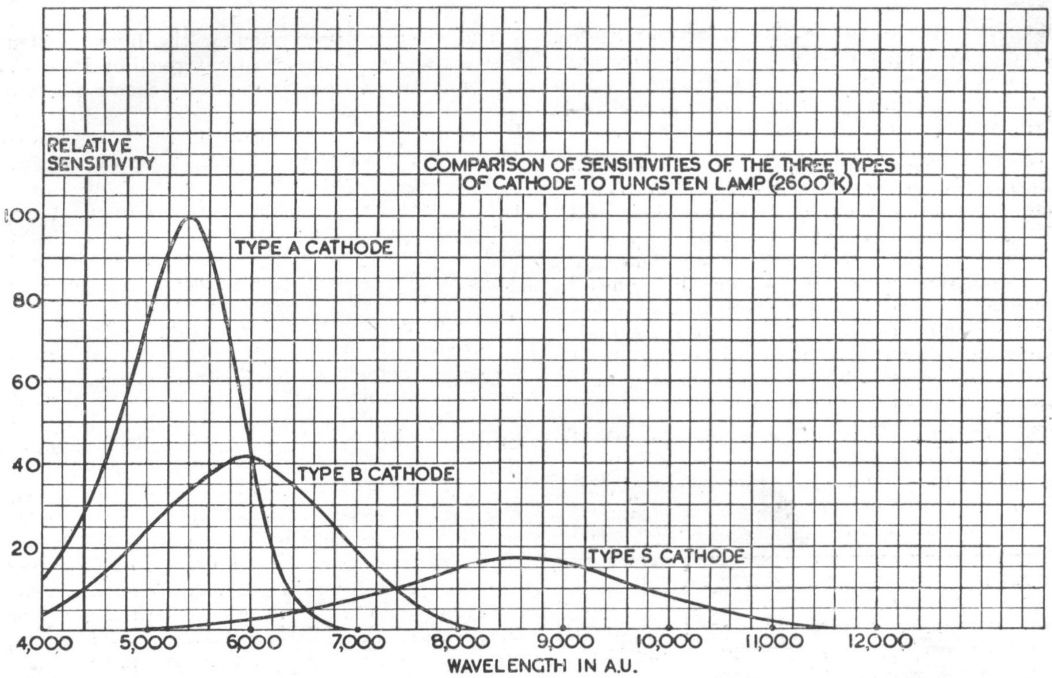



FIG. 8.

to compare the spectral emission curve of the light source with the equal energy curves of the available photo-cells.

I shall now give some practical examples. For incandescent light the $SbCs_3$ cell is superior to the *Ag-O-Cs* cell by a factor 2 to 3; (these figures can only serve as a very rough guide, as they depend on the temperature of the lamp as well as on the individual cell).

For daylight the $SbCs_3$ is about 15 times better owing to the higher temperature of the sun as compared with an incandescent lamp.

For blue fluorescent screens of the type used for cathode ray tube scanning in television transmission, the sensitivity of the $SbCs_3$ cell is more than 200 times higher than that of the *Ag-O-Cs* cell.

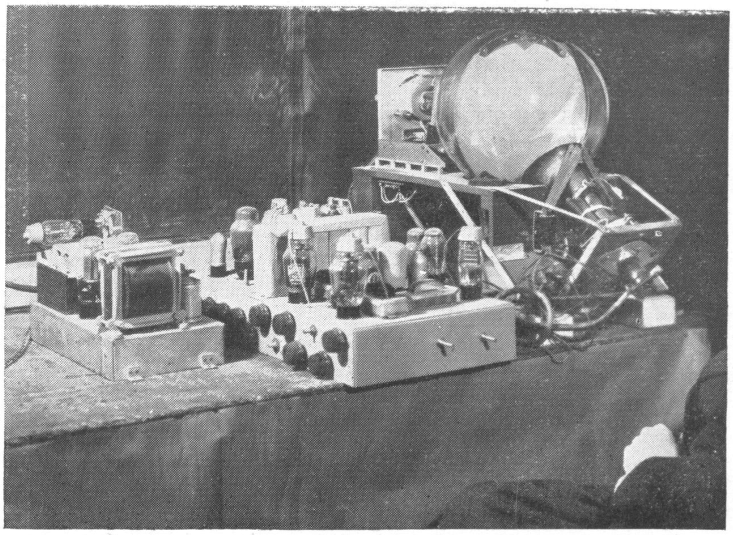
If sensitivity approximating that of the human eye is desired (for instance in colour television and in photometry), the above-mentioned Bismuth-Cæsium cell is most suitable, being sensitive to the whole visible range with a peak not too far from 5500*A*, the wavelength for which the human eye is most sensitive.

For infra-red radiation obviously only the *Ag-O-Cs* cell can be used.

Finally, for detecting ultra violet radiation, the $SbCs_3$ photo-cell is most sensitive. But it must be borne in mind that ordinary glass is only transparent for wavelengths down to 3500*A*. Therefore, in order to utilise the high sensitivity of the $SbCs_3$ photo-cell in the ultra-violet range, the cell has to be provided with a quartz window, or, preferably, it has to be made entirely of quartz.

## POSSIBILITIES OF FUTURE DEVELOPMENTS.

The theoretical limit for the sensitivity of a photo-electric cell is a quantum yield of 100% throughout the visible spectrum. This is obviously a figure that will never be reached because even if every light quantum is actually converted into electronic energy it is unavoidable that some electrons released by absorption of light in deeper layers of the cathode material will lose energy by collisions, with the result that they will no longer be able to overcome the work function. The value of 20% quantum yield obtained for the peak of the $SbCs_3$ cell is the highest that can reasonably be expected. It seems, however, unlikely that this output could be maintained uniformly through the whole visible spectrum because all known surfaces show curves with distinct maxima, apparently due to some resonance effect. The most hopeful field for improvement would therefore lie in the direction of shifting the peak sensitivity from 4600*A* towards a more useful part of the spectrum, that is further towards longer wavelengths.



# J. L. BAIRD'S "TELECHROME"

A new cathode-ray tube for the reproduction of television pictures in colour without the use of rotating filters.

First demonstrated on Wednesday, August 16th, 1944.

IN November, 1942, J. L. Baird demonstrated a colour television system which was designed to avoid the use of rotating colour filters (see this *Journal*, Vol. 3, No. 10, p. 254). This system, which may be called an " electro-optical " system, had the disadvantage that the image was projected through coloured filters, with a resulting loss of light.

The new system, which has been demonstrated, is a purely electronic one, the coloured image appearing directly on the fluorescent screen. This gives a considerably brighter image and by the use of special powders it is possible to compensate accurately for colour addition.

The "Telechrome" television system is entirely electronic, the coloured image appearing directly upon the fluorescent screen. Two cathode-ray beams are required for a two-colour system and three for a three-colour system. These cathode-ray beams are modulated by the incoming signals corresponding to the primary colour picture and impinge on superimposed screens coated with fluorescent powders of the appropriate colours. For example, in a two-colour system the two cathode-ray beams scan the opposite sides of a thin plate of transparent mica one side of which has been coated with orange-red fluorescent powder and the other with blue-green fluorescent powder. Thus the screen has formed upon its front face an image containing the orange-red colour components and on its back face an image containing the blue-green components, these images being superimposed and thus giving a picture in natural colour (*Fig. 1*).

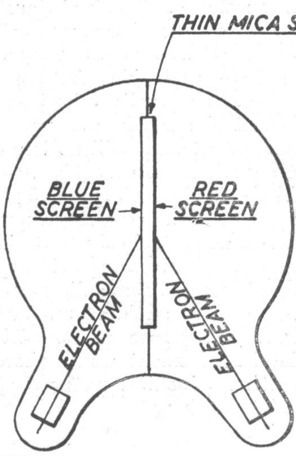
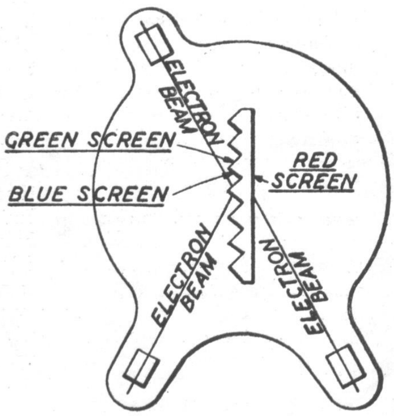



FIG. 1.

*Left.* — Diagram of two-beam tube for two-colour pictures, as demonstrated.

FIG. 2.

*Right.* — Triple-beam tube for full colour pictures with ridged back screen.



Where three colours are to be used the back screen is ridged and a third cathode-ray beam added; the front face of the screen then gives the red components, one side of the back ridges gives the green components, and the other side of the ridges the blue component (*Fig. 2*).

A two-sided tube has been developed to receive a picture from a 600-line triple-interlaced moving spot transmitter using a cathode-ray tube in combination with a revolving disc with orange-red and blue-green filters. The receiving cathode-ray tube is shown in the diagram (*Fig. 1*) and in the photograph. The screen is a 10in. diameter disc of thin mica coated on one side with blue-green fluorescent power and on the other with orange-red fluorescent powder. The colour may alternatively be provided for the back screen by using a white powder and colouring the mica itself.

The tube shown in *Fig. 1* may be viewed from both back and front, but if used in this way one set of viewers sees a mirror image. Also, coloured mica must not be used, and a filter has to be inserted between the back viewers and the tube to keep the colour values correct and compensate for the light lost in the mica and fluorescent powder when the direction of viewing is reversed.

The tube shown in the photograph of the apparatus can only be viewed from the front, but having one cathode-ray beam perpendicular to the screen simplifies the set up of the apparatus. The tubes give a very bright picture due to the absence of colour filters and the fact that special powders are used giving only the desired colours, which are seen additively.

The tubes give excellent stereoscopic television image when used with a stereoscopic transmitter, the blue-green and orange-red images forming a stereoscopic pair and being viewed through colour glasses.

**NEW FORM OF SCANNING.**

In the present form of scanning all the lines in successive frames are of the same colour, the colour changing with each successive frame.

In a new form of scanning now being developed, successive frames are of different colour and the number of lines is made a non-multiple of the number of colours, so that every line of the complete colour picture has successively shown each of the primary colours.

The object of this is to reduce colour flicker. Where frame-by-frame colour alteration is used flicker becomes prominent in any large area of a single colour, for example, if the picture is showing a large blue area, this blue appears in the blue frame only. While the red and green frames are appearing, it is not shown, so that the frequency of the repetition is reduced and flicker accentuated. With line-by-line colour alteration, each colour appears in every frame.

This form of scanning does not lend itself to the revolving filter disc system.

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# TELEVISION AFTER THE WAR

By O. J. RUSSELL, B.Sc. (Hons.)

**Is television dominated by the cinema? An argument for a radical change in picture format and presentation.**

IN the opinion of the writer, the whole position of television as a commercial form of home entertainment has been overshadowed by an unconscious comparison with the cinema. This is rather clearly indicated in many articles dealing with television in its less technical aspects. For example, the choice of screen shape has obviously been chosen purely from the point of view of cinema requirements. Moreover this obsession with the cinema shows up in the majority of articles and discussions upon the home entertainment aspect of television. Upon the beginning of the Alexandra Palace television service, the comparisons of image quality and entertainment value were constantly referred to the cinema, often with a little judicious (or injudicious) bias in favour of television. The writer feels that this cinema complex is so largely unconscious that its influence upon the development of television as a public entertainment service is not realised at all. The purpose of this contribution to the present discussion upon the future of television is to stress rather emphatically the possible results of abandoning a too rigid adherence to the requirements of the cinema.[1]

In research work, it frequently occurs that some factor which has been taken for granted turns out to be the solution to a problem which has been tackled unsuccessfully along the usual accepted channels of attack. Similarly there seems reasonable ground for supposing that certain factors, which may perhaps be assigned to the spheres of æsthetics and psychology, rather than to the sphere of the electronic engineer, have not been considered by those responsible for the present television standards. If this is so, the question of whether a revision of these standards in the light of these new factors is desirable, immediately arises. It must be fairly admitted that when the present system of television was decided upon, television had hardly emerged from the laboratory stage. The final standardisation of transmissions being mainly decided by questions of technical performance, rather than from the aspect of æsthetic satisfaction, especially in view of the limited time in which the dual system transmissions operated before the final standards were agreed upon. So little regard for the æsthetic aspect of television transmission had those in charge of developing Alexandra Palace, that we find frequent references to the limitations imposed by the apparently rather inadequate studio space allotted, the majority of the space being occupied by electronic equipment. It seems clear, therefore, that considerations of the electronic engineer have had full consideration in the technical development of television as a research project, but that the use to which the finished product was to be put was either not considered at all, or when it was considered the cinema so obsessed the minds of those responsible that development of a public entertainment service was gravely retarded. In the discussion upon the future of post-war television at the meeting of the wireless section of the I.E.E., we find that there is clear evidence of the neglect of the somewhat intangible, but extremely important psychological factors by the electronic engineer. Thus Mr. B. J. Edwards reveals that although the optimum viewing distance for the television screen is eight times the screen height, the public tend to take up a position much closer than this. However, we find that, later on, Mr. L. H. Bedford makes the somewhat hopeful statement that "surely the public should not expect a wider viewing angle at home than they would at the cinema", in order to justify certain calculations upon definition of images. The regrettable fact is obvious: Although I seem to remember that the question of optimum screen distance of eight times screen height was carefully considered from the question of definition and viewing angle in average cinema seats, and further that at such a distance it appears that the loss of resolution of the image due to finite spot size is just equivalent to the resolution of the human eye, the human being refuses to function according to the television engineer's design formula, and as a *demonstrable experimental fact* actually takes up a position which is about half that which the engineer has budgeted for. If the reader thinks that the alleged obsession with the cinema has been unduly stressed, the writer finds it a little depressing to find that Mr. L. H. Bedford says that ". . . repeated tests of viewing angle in the cinema . . . finds that an acceptable viewing angle for a good priced cinema seat is six times screen height," especially in view of experimental proof that the public persist in sitting far closer than the theoretical, or perhaps we should say hypothetical viewing distance. Just why the human being persists in this open defiance of electronic design specifications is obviously a

problem involving some of these neglected psychological and physiological factors. Man being equipped with stereoscopic vision, and a well developed ability to judge distances and real sizes quite accurately, is obviously able to feel a real difference between a physically small screen close to him, and a physically large screen at an equivalently large distance away. To neutralise some psychological discomfort at being too far away from the physically small screen, the tendency apparently is to move closer. For the rare case of a one-eyed individual, with a poor sense of distance, viewing a screen in a totally darkened room, the two cases of large cinema screen and small television screen, with equal effective resolutions, should be indistinguishable. To the large majority, however, quite definitely they are not, and as a public service is presumably for the majority, the engineer must be prepared to recast his designs to satisfy the public, rather than the few one-eyed individuals extant.

The position of television appears in many ways to be analogous to the early days of the cinema, when comparisons with the legitimate stage peppered every article upon the future of the cinema, in the same way as the cinema is dragged in as the fundamental yard-stick by which the cloth of television is being neatly cut and tailored to an electronic representation of the cinema. The cinema, however, has by now largely outgrown its adolescent inferiority complex, and it has for years been clear from the writing of critics that the function and technique of the cinema is, by virtue of its technics, inherently different from, although allied to, the stage. Surely then, is it not time for the realisation that television is not merely a cinema show produced by a considerably more clever technical process. The public are not interested in technical miracles, they judge the product presented to them as an entertainment, purely upon an entertainment basis.

If television, therefore, is to have a value and art of its own, rather than to be merely a novel and inefficient form of cinematograph, the present balance of technical, æsthetic and psychological factors as crystallised in the present standards for television, may have to be very drastically altered. Purely upon a technical basis the cinema is streets ahead of anything that television can do when *imitating* the cinema. Briefly then, there can be no argument against television, if it is to become the vehicle for a new art form, appreciating its own limitations and advantages, and capitalising upon them. In view of the negligible attention that has been paid to the full development of television, as a separate and individual form of entertainment, perhaps it may be well to stress the two obvious differences from the cinematographic form of entertainment in which television has clearly apparent advantages peculiar to itself, and which provide a valuable foundation for the evolution of a different and dynamic form of entertainment. The first advantage of television is so obvious that, even before the war, it had become a commercially exploited form of entertainment. I refer naturally to the instantaneous presentation of events of news or topical interest. In addition to sporting events, the Coronation, and the dramatic " scoop " of the return of Chamberlain from Munich were presented, arousing no little lay interest. Moreover it was broadcasts of scenes having an immediate news value, such as sporting events, which were able to attract members of the public upon a paying basis to news cinemas wired for big screen projection. It was painfully apparent, however, that so much of the normal television programme material was so devoid of real entertainment interest, that it would not have attracted the pubic upon a paying basis on its merits as entertainment.

However, owing to the comparative rarity of news events of really widespread appeal, and perhaps also for the need for devoting transmission time by a costly process, in the initial stages, to material having an intrinsic value upon a rather higher intellectual plane than unending images of sports events of all kinds, television should seek also to develop other advantages peculiar to it. One obvious, but neglected aspect of television is that it is fundamentally (as is wireless entertainment) an *intimate* form of entertainment. This aspect is perhaps apparent in the previously mentioned fact that the public unconsciously tend to sit closer to a small screen than might be expected purely from experience based upon large cinema screens. Intimacy, with what we are subconsciously aware as being a much larger than life projected image, that our senses inform us is a quite appreciable distance away, is obviously difficult, especially when the images possess voices of several watts audio power blasting some considerable distance away from the throat of a super-cinema speaker. These factors, of which our senses are aware, must obviously colour our æsthetic appreciation. If the reader thinks that these factors are being stressed unduly, the writer would remind him that the cinema has made dramatic vast scale spectacle its own particular province, and is never really happy unless a " cast of thousands " can be employed for a number of dramatic and titanic sequences. However, if we agree that television must decide to free itself from its psychopathic obsession with the technique of the cinema, then the intimate basis of home cinema entertainment must be exploited by people possessing a good grasp of the factors involved in

good entertainment. Such persons, however, must most certainly not be allied to the cinema industry. From reports from America about the most " ambitious television presentation " so far, it appears obvious that obsession with cinema methods has been carried a step further in an illusory hope of obtaining by hit and miss procedure a magic formula that will solve all the irritating problems connected with the evolution of a thriving television service. It is a somewhat dubious consolation that the experimenters admit that the use of cinema technique of the fade and dissolve type is a rather difficult operation in the absence of generous studio facilities. Perhaps economic limitations may force the hand of television producers into the exploration of the at present somewhat neglected aspects of the art. It appears almost axiomatic that emphasis must lie very largely upon the intimate form of entertainment, which, in fact, did form a very substantial proportion of the television programmes, even in the low definition era. As radio entertainment is itself a fundamentally intimate form of home entertainment, variety acts of the type which are successful upon both stage and the air are a hopeful source for the development of worthwhile stand-by entertainment, while newer forms and variants designed to exploit the peculiarities of television are developed. The employment of women announcers, chosen for eye, as well as ear, appeal, was a half-hearted step in the right direction, although unfortunately not followed up very extensively in the choice of material for programmes. The aims and designs for programmes, as reported in the journals of the time, while full of breezy optimism allied to nebulous prophesying about the presumably remote future (in addition to a few stock platitudes about the marvellous nature of the technical medium employed) did not appear to have any very clear-cut designs for the resolute exploitation of television as a genuine art form. It must, however, be admitted that one or two eminent artists did acutally refer to the need for the evolution of a purely televisionary art form.

Admitting, for the sake of argument, that television must produce a genuine art form if it is to survive as a definite addition to modern life, it is advisable to consider whether or not the technical side of television will be affected by this decision, and secondly whether we can gain any improvement in image quality by exploiting any factors of this nature. The writer is of the opinion that this is the case. As has been already mentioned, the screen shape chosen is that used by the cinema, and no justification for its adoption has ever been produced, other than this excuse. The writer is in favour of boldly abandoning this miserable legacy from the cinema, and adopting a picture format more closely allied to the needs of the nature of proposed television images. From the point of view of presenting programme material of an intimate nature, employing a limited number of performers, and especially one, two or three performers, operating largely in close-up or semi close-up poses, the present picture ratio is absurdly wasteful. For the transmission of the proposed material, we could use a picture aspect ratio in which the picture height is greater than the width in the ratio of 3 : 2. A little experiment will show that almost any head and shoulders portrait can be comfortably, tastefully and pleasingly framed in this picture ratio. Moreover from the point of view of æsthetic satisfaction, upon which text-books of photography take so much space in expounding, such a frame makes a neat and unobtrusive surrounding for a face, enabling the face or faces to be the dominating centre of visual interest.

Practically all portraits are framed in ratios approximating to this projected screen format of 2 : 3, and the general effect is one of general satisfaction. No use of ratios analogous to the present cinema shaped screen occurs to me, and in fact such a use would, in general, be inartistic and inadmissible. Technically, the use of such a ratio is even more important, for not only have we concentrated our interest by eliminating the ugly blank areas of screen on either side of the face, but we have concentrated our scanning field to cover the subject matter more closely and efficiently. Thus, if we are interested in increasing detail, the number of lines can be increased by forty per cent. without increasing bandwidth, giving a worthwhile increase in definition. If we are interested in the use of colour, we can radiate a full colour picture upon the old definition standard without a material increase in band-width. In fact for the same band-width as occupied by the Alexandra Palace transmission, a full colour picture may be radiated using the 2 : 3 ratio picture with a definition of approximately 390 lines. In cases where the expression of a single speaker's face is of paramount importance, as in a political broadcast by the Prime Minister, the face could be made to fit the picture aperture extremely closely, thus concentrating detail upon the most essential features. Moreover such a ratio is capable of transmitting scenes of an extended nature without any difficulty, and is not merely designed to accommodate one or two faces. The writer followed the film, " The Light of Heart," which is of rather a more intimate type of film than the super-spectacle picture, through a mask of this

ratio held at arm's length, and even with this film, designed for the cinema screen, almost no loss of dramatic material was occasioned, in fact, by a careful choice of effective "camera angle," the dramatic interest was in a number of sequences heightened. Such a ratio would therefore present no difficulty for the presentation of a wide choice of material. The extreme case of the low-definition narrow picture, designed for single person shots, may perhaps be mentioned here. The 2 : 3 ratio deserves careful consideration, as in the writer's view it presents a careful balance between gain in definition and æsthetic balance.

However, it may well be argued that the subject matter radiated by the television station of the future should not be tied down to a single aspect ratio, or at any rate to a 2 : 3 ratio. The Dumont flexible system of television, and the use of new time base tubes, such as the signal converter tube,[2] may well provide us with a varied choice of screen formats, tailored to suit requirements, and automatically controlled by pilot impulses from the transmitter end. The writer is firmly of the opinion, however, that the present picture ratio should be scrapped, and that while it may be that for an intermediate period after the war, the old system may be employed for a time, the policy of those responsible should be large-scale trials with a variety of picture ratios and definitions, with practical limitations upon band-widths fully considered. The simultaneous transmission of the same programme upon two standards and formats, one upon the old channel and the new one upon an experimental channel, is one that would provide valuable comparative data. A good case could, of course, be made out for certain other ratios. Thus a square picture has much in its favour, especially as this most effectively employs the round end of a cathode ray tube, much in the same way as the modern 2¼-inch square miniature camera most effectively employs the circular field of view of the camera lens, and balances a number of other factors such as aberration and grain size for efficiency and compactness. By inverting the old screen format of 5 : 4 to get a 4 : 5 picture, which might be of value in the conversion of old receivers (or if a 2 : 3 ratio gives a slightly too narrow horizontal field) we obtain about 25 per cent. increase in definition, and this might just possibly be a valuable compromise between the old ratio and the 2 : 3 ratio, as well as being symbolical of the divergence from cinema mentality. The fact that by the use of an appropriate screen ratio, the use of colour comes within the realm of practical application without undue loss of detail, is a point that may well prove of great importance. The introduction of colour may well prove to be one of the factors that will really popularise television as a public entertainment service. Stereo images, assuming the transmission of images at twice the normal frame rates, would appear to require a rather large increase in band-width for a rather questionable advantage. As purely monochromatic subject matter is very rare, the actual increase in band-width for colour images is rather less than would be expected for the transmission of three separate frames,[3] as the frame repetition rate can be reduced without introducing flicker. A table is attached showing the increase in definition possible by using a number of picture formats for monochromatic, stereo, full three-colour images, and stereo-colour images. Owing to the uncertainty of the exact factor involved, the stereo and colour images have been calculated to the nearest ten lines. The monochromatic figures are more accurate (to within a line in most cases), and are calculated from the formula given by Mr. L. H. Bedford.[4]

BANDWIDTH AND DEFINITION FOR VARIOUS FRAME RATIOS

| Video Band | Plain | Stereo | Full Colour | Stereo-Colour | Format |
|---|---|---|---|---|---|
| 7·6 Mcs. | 1100 | 780 | 760 | 520 | 2 : 3 |
| | 1000 | 710 | 690 | 480 | 4 : 5 |
| | 896 | 640 | 620 | 430 | Square |
| | 800 | 570 | 550 | 380 | 5 : 4 |
| 3·2 Mcs. | 714 | 500 | 490 | 340 | 2 : 3 |
| | 656 | 470 | 450 | 310 | 4 : 5 |
| | 590 | 420 | 410 | 280 | Square |
| | 525 | 370 | 360 | 250 | 5 : 4 |
| 2·5 Mcs. | 632 | 450 | 440 | 300 | 2 : 3 |
| | 592 | 420 | 410 | 280 | 4 : 5 |
| | 520 | 370 | 360 | 250 | Square |
| | 465 | 330 | 320 | 220 | 5 : 4 |
| 1·9 Mcs. | 551 | 390 | 380 | 260 | 2 : 3 |
| | 490 | 350 | 340 | 230 | 4 : 5 |
| | 453 | 320 | 310 | 220 | Square |
| | 405 | 290 | 280 | 190 | 5 : 4 |

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3. P. C. Goldmark, J. N. Dyer, E. R. Piore and J. M. Hollywood, "Colour Television," *Proc. I.R.E.*, April, 1942..
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AFTERTHOUGHT.

Since writing the foregoing article, the writer was impressed by two articles on the subject of television entertainment. The articles in question would appear to be especially illuminating when reviewed in the light of the ideas which the present writer has expressed in the article "The Future of Television."

The first article, "Objectives for Post-War Television," by Worthington Miner, reprinted in the March issue of this Journal, is an effective answer to those who imagine that the development of television is purely a question of radiating signals. While Mr. Miner is more closely concerned with technical limitations, he states plainly that the American experience shows that the general public reaction is one of apathy. This is, in the present writer's opinion, to be expected if television services are merely to be content with presenting an inferior imitation of the cinema. The degree of inferiority being inversely dependent upon the degree of technical development and hence complexity of the television system employed.

However, even should television become technically perfect, we shall merely have produced a rather expensive form of home-cinema, if the cinema mentality continues to dominate television development. The degree to which the cinema complex does actually dominate the development of television programmes is strikingly illustrated by the following quotation from the issue of *Radio News* for April, 1944. The article states: "Since Motion Picture Companies are allied with Television activities on many fronts, complete harmony is expected between the two mediums of entertainment in a showmanship and a technical way. Incidentally, the problem of producing and staging television shows seems to be one of the most difficult to solve at the present time. New York and Hollywood specialists are striving to effect a practical solution." The operative words are obviously "is expected" and the rather neat way in which the word "incidentally" is used to gloss over the obvious difficulties of producing genuine television entertainment, a difficulty which appears to resist even the strivings of the Hollywood specialists.

The writer is of the opinion that better results, for less striving, would be obtained by omitting the cinema specialists from Hollywood, and replacing them by persons possessed of some degree of æsthetic appreciation, together with well developed faculties for independent thought and constructive criticism. The writer is not likely to display a continued interest in television in other than its technical aspects, if the grim prospect of the puerility and vapidity of the average film forming the yardstick and standard for television entertainment, is to materialise in this country.

# Frequencies for Television

## Factors Affecting the Choice of Carrier

It is necessary to decide what sort of a service—in point of range—our projected television stations should give. To consider the question broadly—do we visualise a long-distance television service using the ionosphere as a transmission medium, or do we rule this out and consider the service area of a station to be relatively "local"? We must decide upon the latter alternative, not because a long-distance service will necessarily always be an impossibility, but because, owing to the relative instability of the ionosphere as a transmission medium, present-day technique would not suffice to overcome the resulting distortion to the received picture. Past experiments have shown that selective fading such as is produced by the ionosphere causes the contrast of the received picture to change very markedly, while the existence of a number of different ionospheric paths for the different rays comprising the received signal results in repetition, not only of the subject matter of the picture, but also of the synchronising pulses, so that it is impossible to obtain a steady picture.

Experimental evidence from the reception of London television signals at Riverhead, N.J., indicates that 41·5 Mc/s would only be likely to be propagated by the ionosphere during the winter of years near the sunspot maximum, and that 45 Mc/s would be very near the extreme high limit for such propagation even at that time.

It would seem that frequencies from 50 Mc/s upwards would be the most suitable for the television services of all countries in the middle latitudes of the Northern Hemisphere, and that stations operating on these frequencies could provide a service reasonably free from interference and fading to points very considerably beyond the optical range, the actual range depending on the nature of the terrain.

What would be the upper limit of the desirable frequency band? One can but speculate as to the full requirements of a television service, but it may be that not more than six, and possibly only three, complete channels would be required. Starting with a lower limit of 50 Mc/s, and allowing a band-width of 6 Mc/s for each complete channel (vision and sound) would mean an extreme upper limit of 86 Mc/s, and perhaps no higher than 68 Mc/s. It seems that the production and operation of transmitters and receivers at frequencies of that order would be well within the bounds of post-war possibility.

—*Wireless World*, Vol. 50, No. 4, April, 1944, p. 98.

# TELEVISION TERMS and DEFINITIONS

A Committee of the British Standards Institution, on which the Society was represented, has recently been engaged in revising the British Standard Glossary of Terms used in Telecommunication. This Glossary has now been published (BS. 204 : 1943), and the section dealing with Television Terms is reproduced below by kind permission of the British Standards Institution.

Copies of the Glossary are obtainable, price 3/6 post free from the B.S.I., 28, Victoria Street, S.W.1.

Some Television terms are also listed in "American Standard Definitions of Electrical Terms," issued by the American Institute of Electrical Engineers, and these are given in their appropriate place in italics for comparison with the British definitions.

| TERM. | DEFINITION. |
|---|---|
| **Television** ... ... ... ... | The art of instantaneously producing at a distance a transient visible image of an actual or recorded scene by means of an electrical system of telecommunication.<br><br>*The electric transmission and reception of transient visual images in such a way as to give a substantially continuous and simultaneous reproduction to the eye at a distance.* |
| **Television transmitter** ... ... | Apparatus for the emission of an electrical signal which represents a visible image or recorded scene. |
| **Television receiver** ... ... | Apparatus for receiving an electrical signal emitted by a television transmitter and reproducing it in the form of a visible image. |
| **D.C. component** ... ... ... | That component of the visual signal which is proportional to the general level of illumination of the screen. |
| **Positive transmission** ... ... | A system of transmission in which the amplitude of the emitted wave is inversely proportional to the light intensity of the picture element.<br><br>*Positive light modulation occurs when an increase in initial light intensity causes an increase in the transmitted power.*<br><br>*Negative light modulation occurs when a decrease in initial light intensity causes an increase in the transmitted power.* |
| **D.C. transmission** ... ... | A system of transmission of a visual signal in which a signal corresponding to the D.C. component is present in the emitted wave. |
| **Velocity modulation** ... ... | A system of television transmission in which the brightness of the reproducing spot remains constant throughout the scan, the variation in brightness in the picture being produced by varying the velocity of traverse of the spot. |
| **Scanning** ... ... ... ... | (a) In a transmitter. The process of analysing the scene or object into elements which are then represented in succession by the magnitudes of an electrical signal.<br><br>(b) In a receiver. The process of building-up the image from elements derived in succession from the received signal.<br><br>*The process of successively analysing, according to a pre-determined method, the light values of picture elements constituting the total picture area.* |
| **Sequential scanning** ... ...<br>Progressive scanning.<br>Straight scanning. | A system of scanning in which each complete picture is represented as analysed by means of one frame.<br><br>*Rectilinear scanning is the process of scanning the area in a pre-determined sequence of narrow parallel strips.*<br><br>*Progressve scanning is that in which scanning lines trace one dimension substantially parallel to the side of the frame and in which successively traced lines are adjacent.* |

| | |
|---|---|
| **Interlaced scanning** ... ... <br> Non-sequential scanning. <br> Intercalated scanning (deprecated). | A system of scanning in which each complete picture is represented as analysed by means of two or more frames in succession, with the scanning lines in one frame in the gaps left by the scanning lines of other frames. |
| **Scanning-field** ... ... ... | The area explored by the scanning apparatus at the sending or receiving ends. |
| **Scanning-line** ... ... ... <br> Picture-strip. | A sequence of picture-elements extending throughout one dimension of the picture and represented by successive signal values. <br> *A scanning line is a single continuous narrow strip which is determined by the process of scanning.* |
| **Frame** ... ... ... ... ... <br> Raster, Field (U.S.A.) | The line structure formed by a single sequence of scanning-lines. |
| **Aspect ratio** ... ... ... ... | Of the picture. The ratio of the breadth of the picture to the height of the picture. <br> *The aspect ratio of a frame is the ratio of frame width to frame height.* |
| **Picture-element** ... ... ... <br> Elemental area. | That area of the picture which is equivalent to a square the side of which is equal to the distance between adjacent scanning-lines. <br> *A picture element is the smallest subdivision of a television image arbitrarily defined by assuming equal vertical and horizontal resolution, the resulting elemental square having a dimension equal to the width of one line.* |
| **Dot-frequency** ... ... ... | Half the number of elements transmitted per second. |
| **Line-frequency** ... ... ... <br> Strip-frequency (deprecated). | The number of scanning-lines traversed per second. <br> *Line frequency, in rectilinear scanning, is the number of scanning lines traced in one second.* |
| **Frame-frequency** ... ... ... <br> Field-frequency (U.S.A.) | The number of scannings of the frame by the scanning-beam per second. In interlaced scanning the frame-frequency is an integral multiple of the picture-frequency. |
| **Picture-frequency** ... ... ... <br> Frame-frequency (U.S.A.) | The number of complete images transmitted per second. <br> *Frame frequency is the number of times per second that the picture area is completely scanned.* |
| **Vision-frequency** ... ... ... <br> Video-frequency. | The frequency of any single frequency-component of the electrical signal produced by a scanning device. |
| **High-definition television** ... | A system of television in which the number of scanning-lines exceeds 200 for each picture. |
| **Low-definition television** ... | A system of television in which the number of scanning-lines is less than 200 for each picture. |
| **Flicker** ... ... ... ... | In the received image. The appearance produced when the presentation of successive frames is noticeable to the eye. |
| **Phasing** ... ... ... ... | That process by which the formation of the image is brought, point for point, into the same time-and-position relationship as the scanning of the object. |
| **Framing** ... ... ... ... | The process by which that portion of the scanning device upon which the phased image is formed is brought into an allocated relationship with a fixed screen. |
| **Isochronism** ... ... ... | The operating condition which obtains when the reconstruction of the image and scanning of the object occur at the same rate. |
| **Synchronism** ... ... ... | The condition which obtains when the requirements of phasing, framing and isochronism are complied with. |
| **Synchronising signal** ... ... <br> Sync-pulse. | A signal sent out periodically by the transmitter in order to keep the receiving system in synchronism. It usually consists of a series of pulses incorporated in the vision-signal. |

*Television Terms and Definitions.*

| | |
|---|---|
| **Blanking** ... ... ... ... | Suppression of the vision-signal at the end of a line or frame to eliminate disturbances due to flyback or other unwanted effects. |
| **Aperture distortion** ... ... | The reduction of definition due to the finite size of the scanning spot or aperture in the direction of scanning. |
| **Vision pick-up** ... ... ... Television camera. | The apparatus used in connexion with a transmitter for the production of vision-frequencies as a result of scanning. |
| **Image dissector** ... ... ... | A vision pick-up in which the picture is projected optically upon a photo-electric cathode. The resulting photo-electrons are accelerated, focused and deflected in such a way that they impinge in succession on a collecting electrode. |
| **Mosaic electrode** ... ... ... | A cathode consisting of a number of insulated particles each one of which corresponds to a picture-element or to part of a picture-element. |
| **Storage camera** ... ... ... Iconoscope. | An electronic vision pick-up in which the picture is projected optically upon a mosaic electrode which is scanned by an electron beam. |
| **Gamma** ... ... ... ... | The relationship between the brightness contrast of two points on the transmitted scene and the brightness contrast of the corresponding points on the receiver screen. If $S_n$ represents brightness of a point in the scene to be transmitted and $R_n$ represents the corresponding brightness in the received picture then $\text{gamma} = \frac{\log R_2 - \log R_1}{\log S_2 - \log S_1}$ |
| **Kerr cell** ... ... ... ... | A device in which the rotation of the plane of polarisation of a beam of light is controlled by an electric field. |
| **Supersonic cell** ... ... ... | A light-control device utilising the diffraction effect of a train of supersonic waves in a liquid. |
| **Blocking oscillator** ... ... | A type of oscillator in which oscillations are generated by the charging of a capacitor through an impedance followed by the discharging of the capacitor through another impedance, and used in conjunction with an electronic device to produce a scanning-field. |

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## SENSITIVITY OF THE HUMAN EYE.

Dr. Selig Hecht, professor of biophysics at Columbia University, gave some interesting data, arising from his own researches, on the sensitivity of the eye. Under the most favourable conditions, the smallest amount of light which the human eye can detect is 58–148 quanta, representing an energy of 2–6 $\times$ $10^{-10}$ ergs. This 58–148 quanta is the amount of light falling on the cornea, but only about 10 per cent. (5–14 quanta) of this is actually absorbed by the retina; the rest is lost by corneal reflexion (4 per cent.), absorption by ocular media (50 per cent.) and passing on beyond the retina (36 per cent.). In the particular experiments described, this 5–14 quanta were absorbed by an area of retina which contained about five hundred receptor cells (rods). It seems reasonable to suppose, therefore, that each quantum was absorbed by a separate receptor cell. Chemical studies have shown that one quantum of light changes (bleaches) one molecule of visual purple. The conclusion reached is that we can see a light when the energy from it is sufficient to bleach one molecule of visual purple in each of 5–14 separate receptor cells. —*Nature*, July, 1944.

# A.I.E.E.—I.R.E. TELEVISION LECTURES

A series of lectures on Television was recently sponsored in America by the American I.E.E. and the Institute of Radio Engineers. The following summary has been taken, with acknowledgements, from *Communications*,* in which a fuller report is given.

## Television Principles.

by P. Mertz *(Bell Labs.)*

In this, the first lecture of the series, Mr. Mertz discussed the principles of television and showed how the present system had evolved from the early attempts of von Carey (1875), Nipkow and others. In 1927 the Bell Company used an experimental system of 50 lines 17·5 frames per sec., with a band of 20 kc/s. In 1930 a 72-line system 18 frames per sec., with a band-width of 40 kc/s was developed, and from then on the number of lines steadily increased until the present standard of 525 lines (1941). Mention was also made of contemporary British standards.

## Television Pickups.

by R. E. Shelby *(N.B.C.)*

This paper dealt with flicker frequency, resolution, and picture time factors before describing the iconoscope and image dissector. The method of transmitting film by the iconoscope was described, based on the storage property of the iconoscope mosaic. A saw-tooth controlling wave-form was used with the film shutter open for only 7% of the time of scan. The shutter opens 60 times per second, but the frames remain for either 2 or 3 openings in the alternate series: 2, 3, 2, 3, 2 . . . . . of the film projection cycle. This scheme matches the 24 pictures per second of the film to the 30 pictures per second of the television system. (U.S. standard).

## Television Broadcasting.

by J. E. Keister *(G.E.Co.)*

The problems met in high level anode modulation, low level anode modulation, and high level grid modulation were analysed by the lecturer. He pointed out that high level anode modulation is a low distortion system capable of 100 per cent. modulation which, in a sound transmitter, requires half as much audio power as the anode input to the final r.f. power amplifier. In a video transmitter the power required is enormous, as the following example will show:—

Suppose a modulator looks into a hypothetical resistance which, for sound, is $E_{dc}$ divided by $I_{dc}$. The equivalent resistance for the video band is:—

$$R_v = \frac{1}{2\pi f_v C_a} = 30 \text{ ohms approx.}$$

where $R_v$ is the modulator load, $f_v$ the video band width (taken as 4 Mc/s). and $C_a$ the anode capacity of the modulator.

Thus from the expression $P_v = E^2_{dc}/R_v$, where $P_v$ is the video power, the modulated power would be in the neighbourhood of 500 kW for a 10 kW carrier with an anode voltage of 3860.

Further, no present valve can work efficiently into such a low value of load and no transformer is yet available to handle the power at such a frequency range.

In grid modulation of the power stage, the capacity is of the same order, but the voltage is reduced to about 10 per cent., making the power required about 50 kW.

A high $Q$ in the power amplifier is not possible due to the r.f. load being equal to $1/2\pi\Delta fC$ for a single tuned circuit, where $\Delta f$ is the bandwidth on either side of the carrier. For a double tuned circuit, the r.f. load is $0{\cdot}14/\Delta fC$ ohms.

Since the power is $\frac{1}{2}I^2R$ where $I$ is the fundamental component of the anode current of one valve, and $R$ has the values given above, the power output is limited by the current in the power amplifier valves.

The difficulties encountered with low level anode modulation are encountered in the Class B amplifiers required to build up r.f. power. Single-tuned circuits sharpen up too much when cascaded and it becomes necessary to use double or triple tuned band-pass filters which do not cut the side-bands. In double or triple tuned amplifiers only the output capacity of the valve appears across the coupling transformer, whereas in single tuned systems both the output capacity and the input capacity of the next valve are present to lower the gain.

* April—July, 1944.

Since very low load impedances are required to pass the very wide band, the value can be neglected in calculating power gain. Thus:—

$$\text{Gain} = \frac{0.013\, G_m^2}{(\Delta f)^2 C_0 C_1}$$

where $G_m$ is the transconductance, $C_0$ the input capacity, and $C_1$ the output capacity.

### Studio-Transmitter Links.

by H. D. Fancher (*G.E.Co.*)

For short distances it is conventional to pipe the video and sync. signals through coaxial cable with a studio output of 1–5 volts. For longer distances a radio link is used.

When cables are laid in the street it is essential to earth the sheath at only one point in order to minimise hum pickup. At the transmission end of the cable, a high gain pentode used in a cathode-follower circuit is used to match the line impedance with very little loss. At the receiving end, a terminating resistor is used. The advantage of cathode coupling is that it is insensitive to ordinary circuit changes and to changing of valves.

Cable transmission without equalisation is not possible and it is necessary to boost both the low and high frequency ends of the band with proper phase correction. For the longer distances, a modulated carrier is used instead of straight video frequency, with repeater stations every 4–6 miles.

The FCC provides for r.f. studio links and relay channels in the 162-300 Mc/s band. Powers of 10 to 50 watts are sufficient for distances up to 20 miles owing to the highly directive aerial systems employed at each end. At these wavelengths the structures are small, which tends to cut down interference from local transmitters.

### Colour Television.

by P. C. Goldmark (*C.B.S.*)

Dr. Goldwark recapitulated the development of the C.B.S. colour television system and compared the various experimental systems tried out.

An interesting point was that after an hour or so a control operator in monitoring colour pictures loses colour sense, so that it is necessary to supply a white light for reference purposes. Without this reference the operator will frequently adjust the colour mixer so that white appears as light pink or some equivalent colour. It is possible that programme directors will wish to manipulate the mixers to produce a desired colour effect.

In discussing magnifying lenses at the receiver, it was stated that too much magnification was undesirable: about $1\frac{1}{2}$ to 1 would seen about the optimum.

### Television Reception.

by T. T. Goldsmith (*du Mont Labs.*)

This speaker reviewed the requirements of video amplifiers and receivers. A typical r.f. stage consists of a 6AC7 or 1852 tightly coupled to the aerial, the r.f. transformers being tuned for mid-band with a double hump to take care of a 5 Mc/s channel for picture and sound. A tertiary winding is often used to broaden the band-width.

In eliminating the lower sideband half, the transmitted energy is lost, necessitating twice the amplifier gain. This, however, is not serious compared with the requirements of passing an 8 Mc/s band which would be required with both side-bands transmitted.

In present receivers the i.f. gain is approximately 6, five stages being employed. Midget tubes are popular because their lower input and output capacities more than make up for the lower $g_m$. Trap circuits are commonly used in one or two i.f. stages to keep the sound carrier out of the video channel, an 8·25 Mc/s trap being used for the receiver station sound and a 14·25 Mc/s trap for the sound from an adjacent channel.

## PROPOSED STANDARDS FOR POST-WAR AMERICAN TELEVISION

The Television Panel of the Radio Technical Planning Board (D. B. Smith, Philco, Chairman), have issued recommendations for a nation-wide television service including 26 commercial channels from 50–246 Mc/s., with relaying and experimental channels extending above 10,000 Mc/s.

A summary of the recommendations for television standards is given below:—

Width of standard channel—6 Mc/s.
Lines per frame—525.
Interlacing—2 : 1.
Frame Frequency—30.
Field Frequency—60.
Aspect Ratio—4 : 3.
Scanning—Left to right and top to bottom.
Transmission—Decrease in light intensity causes an increase in radiated power.
Transmission—Horizontal polarisation.
Transmission—Black level 75% of carrier peak.
Sound—Frequency modulation, with a maximum frequency swing of 25 kC/s.

A fuller report will be given in the next issue of the Journal.

# AMERICAN TELEVISION NOTES

## Television Survey by N.B.C.

Approximately 4,500 questionnaires were recently sent out by the N.B.C. to obtain up-to-date information on the present position of television in America.

32% of the forms were returned, with the following results:—

| | |
|---|---|
| Make of receiver owned: | % |
| R.C.A. | 60·7 |
| DuMont | 10·4 |
| G.E. | 10·2 |
| Andrea | 5·9 |
| Westinghouse | 1·4 |
| Other Makes | 10·9 |
| Size of Screen: | |
| Over 12 inches | 3·9 |
| 12 inches | 50·2 |
| 9 inches | 20·5 |
| 5 inches | 22·5 |
| Uncertain | 2·9 |
| Present operating conditions: | |
| Excellent | 66·7 |
| Fair | 14·1 |
| Poor | 4·8 |
| Not Operating | 11·2 |
| Uncertain | 3·2 |

Size of audience:

92% reported an average audience of eight people.

78% of public places reported an average audience of 46 viewers.

There are approximately 5,000 receivers in the New York area, 800 in the Philadelphia area, and 400 in the Albany-Troy-Schenectady area.

*Electronic Industries*, June, 1944.

## R.K.O. Television Corporation.

The Radio-Keith-Orpheum Corporation have announced the formation of a subsidiary company—the R.K.O. Television Corporation.

The President is F. Ullman, Jr., President of Pathe News, Ic., and the Vice-Presidents, R. B. Austrian and M. Kingsberg.

" Since the entire activity of R.K.O. is the regular business of . . . . motion pictures, R.K.O. believes that it is pre-eminently qualified to develop the new art form that television is planning. . . . . It has decided to make available to the producers of television entertainment a complete programme-building service."

## Columbia Television.

A beautifully produced booklet with colour illustrations has been issued by the Columbia Broadcasting System. In the preface it is stated that the book has been prepared " to bring into the open discussion which has largely gone on behind closed doors, to make clear to the layman what has hitherto been the knowledge of television engineers, and to inform the purveyors of television programmes how much is at stake."

Comparisons are drawn between pre-war and post-war definition and pre-war black-and-white and post-war colour, describing briefly the Columbia Colour System (*see this Journal, Vol. 3, No. 10, p. 257*).

In a discussion on post-war improvements in television pictures, the C.B.C. does not belittle any of the reasons for preserving the pre-war *status quo*, but believes that all of them combined do not offset the rule of public service which demands the best end-product that any industry can give.

An appendix deals with such questions as: Do half-tone plates flatter television images?—When does colour have no advantage over black-and-white?—How fine a screen for theatre television?

The booklet is a serious contribution to post-war planning and an excellent example of what can be done in good half-tone colour work.

## Film Premiere by Television.

The first film première presented by television took place in April, 1944, when the M-G-M short feature " Patrolling the Ether " was televised by the NBC station WNBT. The film is the dramatised story of the Radio Intelligence Division of the FCC, who run down illegal transmitting stations, and shows some of the novel methods used in searching.

The picture was picked up and re-broadcast from WRGB, Schenectady and WPTZ, Philadelphia, and local stations in Chicago and Los Angeles transmitted the film during the evening broadcast.

—*Electronics*, June, 1944.

# POST-WAR TELEVISION

## The Brit. I.R.E. Proposals.

IN the last issue of the *Journal*, brief particulars were given of the recommendations put forward to the Advisory Committee by the British Institution of Radio Engineers.

The following amplified statement is taken from their recently issued Report on Post-War Development in the Radio Industry, copies of which can be obtained from the Secretary, 9, Bedford Square, W.C.1:—

Great Britain established a lead in television development prior to the war. This position must be regained as quickly as possible. To this end a broad policy should be decided upon immediately.

There is a real need for a television service, broadly of a pre-war character, that is, having the following characteristics in common with 1939 standards:—

(*a*) That the service be "broadcast," i.e., there shall be a (generally) non-directional transmission without wires.

(*b*) That the vision and sound transmissions be of the same order of carrier frequency as pre-war. With regard to the assignment of any new frequencies required, a conservative policy is advocated having regard to the possibility of echo trouble at higher carrier frequencies.

(*c*) That the radio bandwidth for vision transmission be of the same order as pre-war, viz., 4 Mc/s approximately.

Serious consideration should be given to better utilisation of the above-mentioned bandwidth by making use of vestigial side-band transmission and also to increasing the number of lines to that which is optimum for the increased modulation bandwidth.

Tentative figures proposed are:—

525 lines (gross, interlaced).

3·25 Mc/s, maximum modulation frequency.

All other standards relative to the vision transmission should be maintained at pre-war values.

The television sound transmission should be regarded as part of a nation-wide U.H.F. high quality sound service and should, therefore, be of whatever character (viz., Frequency, Amplitude or Pulse Modulation) is selected for that sound service. But that, in the case of London, in addition to any new sound channel, the London Service should radiate on a duplicate sound channel the original amplitude-modulation transmission.

The television services should be extended to the provinces with the utmost possible speed.

The above recommendations, referring specifically to domestic use, will provide picture entertainment of a high order and yet allow modification of existing television receivers with a minimum of difficulty.

The recommendations are based on the consideration that the future of (domestic) television is dominated more by economic than by technical factors. The more ambitious schemes which have recently been propounded are likely to be at a distinct cost disadvantage to the public in comparison with the above more moderate proposals and should, therefore, be considered as separate rather than replacement services.

The more advanced developments in the fields of Stereoscopy and Colour will also require provision of an alternative service to cinemas.

It is suggested that the immediate post-war television standard will, in fact, be permanent; it is, therefore, desirable that these standards should not be "frozen" at a level which is below the technical and economic limits of the present time.

If television is to recommence on a sound basis, it must be given a semblance of stability. The marketing of sets giving poor reception, having low reliability or lacking good service arrangements, will harm not only the manufacturer in question, but the whole industry. In the early post-war days, every individual set will be a centre of interest, and an advertisement for television in general.

In view of the problems involved, it will undoubtedly pay the industry to adopt co-operative research methods in regard to television. If this were done, agreement could, for example, be reached upon the main types of circuits to be used, thus giving the public the best of co-operative effort. Moreover, by avoiding fancy and unreliable circuits the task of service mechanics would be made much easier.

Any apparent loss of privately acquired knowledge that may occur as a result of co-operative research is thus seen to be, in fact, a sound investment at this stage of the art.

# ABSTRACTS

**Television Pickups.**

R. E. Shelby. *Communications*, V 24, No. 4, p. 36, 1944.

Discussion on scanning, flicker rate, etc., of various cameras.

**Television Broadcast Coverage.**

Du Mont and Goldsmith. *Proc. I.R.E.*, V. 32, No. 4, p. 193, 1944.

Survey of three transmitters in N.Y. area: multipath problem and effect of ghosts. It is stated that lower frequency channels provide least multipath interference in metropolitan territory.

**Three Years of Television Relaying.**

R. L. Smith. *Electronics*, V. 16, No. 9, 1943, p. 122.

Experience gained in relaying programmes between N.Y. and Schenectady.

**Television To-day.**

J. Frank, Jr. *Int. Projectionist*, V. 19, No. 2, p. 12, 1944.

Operating procedure and applications of image dissector.

**R.C.A. Theatre Television.**

I. G. Maloff and W. A. Tolson. *Int. Projectionist*, V. 16, No. 6, 1941, p. 19.

**Ultimate Bandwidths in Multi-stage Video Amplifiers.**

W. R. Maclean. *Proc. I.R.E.*, V. 32, No. 1, p. 12, 1944.

Design of high-gain video amplfiers, giving a rule for determining the optimum number of stages for max. bandwidth.

**A Type of Light Valve for Television Reproduction.**

J. S. Donal. *Proc. I.R.E.*, May, 1943, p. 195.

The desirability of a light valve for the reproduction of television pictures is discussed, and the use of a suspension of opaque plate-like particles for this purpose is shown to offer the particular advantages that the electron beam would be only a control mechanism and the picture brightness would be limited only by the light source and lens system.

The theory of operation of such a suspension is described and it is demonstrated that inertial effects may be neglected and that the rate of orientation of the particles is independent of particle size and is a function of the viscosity and dielectric constant of the suspending medium and of the square of the applied voltage. The contrast ratio obtained may be made very high, although the optical efficiency will decline as the contrast ratio rises.

It is found that suspension resistivity must be considered in practical application of the light valve, for if the field is applied through an insulating wall the valve will respond only to changes in potential of the outside wall, since leakage will prevent a constant wall potential from maintaining a field across the suspension.

From the results of tests, the conclusions are drawn that the fundamental optical behaviour of the suspensions considered is in accordance with the predictions of a theory based on simple assumptions, and that the suspensions fulfill the basic requirements of a television light valve.

**Cathode-Ray Control of Television Light Valves.**

J. S. Donal, Jr. *Proc. I.R.E.*, May, 1943, p. 195.

When a light valve is employed for the reproduction of television pictures, it is desirable to make use of a cathode-ray beam to control the light valve in order to preserve the all-electronic character of the television system. A number of procedures of cathode-ray control are described, the majority of which are applicable particularly to the control of the suspension light valve.

The general method employed is shown to be the production of an electric field through the light valve by bombarding one side of the valve with electrons of very high velocity, causing the valve areas to be charged in a negative direction toward the limiting potential of the bombarded surface. Removal of the electric field is then accomplished by charging these areas back toward their original potential by the use of substantially reduced velocity.

The most elementary procedure described is one in which a single beam of electrons of constant velocity is employed, discharge being accomplished by secondary electrons generated by the action of the beam of primary electrons.

The effects of polarisation of the light valve, resulting from the comparatively low resistivity of the suspension, are described and explained. It is shown that a suspension of such low resistivity as to be uncontrollable by the other procedures may be made operative when the valve is used in combination with a spatially modulated electron spray and when, in addition, the potential of one wall of the valve is increased and decreased at a moderate frequency.

Of the procedures described, the most effective from the practical standpoint is shown to be one in which the light-valve field is developed by a scanning beam, and in which the field is later removed by rescanning with the same beam at a reduced electron velocity. A photograph is shown of a picture reproduced by the light valve when controlled by this method.

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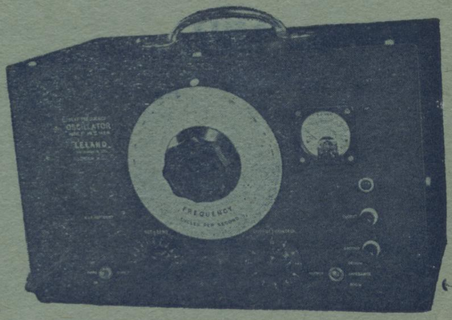

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